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ASTROMETRIC OBSERVATIONS OF COMETS AND ASTEROIDS AND SUBSEQUENT ORBITAL INVESTIGATIONS

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Final Report

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Principal Investigators

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Final Report

1. *Personnel*

Observations, data reduction and interpretation of results contributing to this research were performed under the general direction of Principal Investigator B. G. Marsden. Almost all of the observations were made by Co-Investigator R. E. McCrosky, whose retirement in December 1996 was the principal reason for terminating this observing program with the 1.5-m reflector at the Oak Ridge Observatory in Massachusetts in 1997. Until 1994 C.-Y. Shao also participated in the observing program. In 1996 and 1997 some observations were made, mainly by C. W. Hergenrother, with the 1.2-m reflector at the Whipple Observatory in Arizona. The selection of objects to be observed and the verification of the results were made through 1996 mainly by C. M. Bardwell. D. W. E. Green and G. V. Williams also participated in this, the latter completing the work in 1997 and carrying out the majority of the orbit computations from 1990 onward.

2. *Observing Program*

An earlier series of photographic observations was made with the 1.5-m reflector from 1972 to 1989. The start of the series to which this report refers occurred shortly before the conversion from photographic to CCD operation in August 1989, at which point there was a dramatic increase in the productivity of the program. This is evident from Table 1, which gives a month-by-month summary of the observations; the earlier data refer to the measurement or remeasurement of photographic plates previously taken with the same telescope. The total number of observations made was 24 423, of which 1338 were of comets. Of the 23 085 observations of asteroids, 21 529 referred to asteroids that were unnumbered when the observations were made. Since an important emphasis of the program was to improve knowledge of the orbits to the point where asteroids can be numbered, the fact that only 4262 of the observations refer to asteroids that are still unnumbered is a measure of the program's success, with 30–35 percent of *all* the new numberings being habitually made *solely* because of the recent data from the Oak Ridge program, which even at the time of McCrosky's retirement was still the fourth largest comet-asteroid astrometric program in the world.

3. *Publications*

Observations were published on *Minor Planet Circular* 14385, 14390–14391, 14432–14433, 14519, 14521–14522, 14561, 14670–14671, 14733, 14821–14822, 14878, 14979, 15031, 15131, 15134, 15181–15182, 15285, 15332, 15441–15442, 15506, 15603, 15605–15606, 15630–15631, 15827, 15856, 15981–15982, 16123–16126, 16150–16156, 16346, 16481–16483, 16530–16537, 16656, 16677–16678, 16774–16775, 16828–16830, 16935–16936, 16938, 16988–16992, 17086–17087, 17133–17136, 17275–17276, 17278–17280, 17349–17356, 17488–17492, 17565–17577, 17684–17687, 17721–17725, 17854–17856, 17908–17913, 18011–18014, 18062–18068, 18165–18167, 18209–18212, 18325–18326, 18352–18356, 18492–18496, 18566–18574, 18665–18668, 18741–18747, 18850–18853, 18918–18925, 18972, 18980, 18993–18994, 19056, 19066–19071, 19200–19206, 19359–19364, 19366, 19440–19447, 19560–19564, 19631–19638, 19727–19731, 19783–19787, 19912–19915, 19972–19976, 20061, 20110, 20192–20194, 20291–20296, 20445–20448, 20456–20457, 20542–20546, 20587–20595, 20671–20673, 20745–20752, 20855, 20860, 20864, 20890–20891, 20962–20966, 21051–21063, 21158–21159, 21163–21165, 21222–21226, 21306–21307, 21311–21312, 21314–21315, 21386–21395, 21632–21636, 21733–21741, 21831, 21833–21836, 21887–21894, 21979, 21983–21987, 22021–22025, 22116–22118, 22120, 22187–22190, 22281–22282, 22285, 22359–22363, 22375, 22381, 22439–22440, 22465–22468, 22520–22521, 22556–22559, 22610–22611, 22613–22614, 22648–22655, 22713–22714, 22717–22719, 22771–22775, 22900–22902, 22985–22986, 22992, 22998–23000, 23072, 23157, 23195–23196, 23260–23261, 23263–23264, 23302–23305, 23365, 23370, 23431–23435, 23552–23554, 23562–23563, 23565–23567, 23613–23618, 23698, 23709–23710, 23731–23733, 23826–23829, 23882–23883, 23930–23934, 24024–24025, 24051–24055, 24210–24211, 24253–24254, 24326–24328, 24501–24502, 24599–24600, 24604, 24667–24669, 24857–24858, 24934–24935, 25020–25024, 25097–25098, 25171–25179, 25248, 25250, 25289–25290, 25353, 25399–25401, 25509–25510, 25558–25559, 25613–25619, 25675, 25708–25711, 25747, 25751, 25885–25890, 25995–25997, 26117–26122, 26209–26212, 26358–26361, 26443–26444, 26446, 26538, 26601, 26610, 26612, 26711–26713, 26783–26785, 26787–26790, 26866–26871, 26949–26950, 26952, 26954–26955, 27071–27074, 27152–27153, 27244–27246, 27348, 27350, 27420–27421, 27479–27480, 27525–27527, 27584, 27589, 27670–27672, 27751, 27870–27871, 27952–27955, 28033–28035, 28119–28121, 28234–28236, 28643, 28645, 28794–28795, 29061, 29337, 29862, 30029, 30212–30213. Some of the observations were initially published also in the *IAU Circulars* or *Minor Planet Electronic Circulars*. Orbit computations appeared more generally in these publications, as well as in the *IAU Circulars*.

TABLE 1. SUMMARY OF OAK RIDGE OBSERVATIONS

Number of nights per darkrun:

Month	# obs		Nights	Ave	Best night	
1934-1986	45	609	33	1.4		
1987 Jan.	4	49	2	2.0		
1987 Feb.	6	55	2	3.0		
1987 Apr. - May	3	58	2	1.5		
1987 June	2	60	1	2.0		
1987 Aug.	3	63	3	1.0		
1987 Sept.	1	64	1	1.0		
1987 Oct.	2	66	2	1.0		
1987 Nov.	1	67	1	1.0		
1987 Dec.	2	69	2	1.0		
1988 Feb.	2	71	1	2.0		
1988 Mar.	1	72	1	1.0		
1988 Apr.	4	76	3	1.3		
1988 June	2	78	2	1.0		
1988 July	3	81	2	1.5		
1988 Aug.	3	84	3	1.0		
1988 Sept.- Oct.	2	86	2	1.0		
1988 Nov.	1	87	1	1.0		
1988 Dec.	2	89	2	1.0		
1989 Jan.	1	90	1	1.0		
1989 Feb.	8	98	2	4.0		
1989 Mar.	46	144	7	6.6	17	1989 Mar. 9 - 10
1989 Apr.	17	161	5	3.4	7	1989 Apr. 8 - 9
1989 May	28	189	5	5.6	11	1989 May 4 - 5
1989 June	15	204	3	5.0	8	1989 June 2 - 3
1989 June - July	27	231	7	3.9	8	1989 July 8 - 9
1989 July - Aug.	30	261	6	5.0	8	1989 July 28 - 29
1989 Aug. - Sept.	53	314	5	10.6	14	1989 Sept. 3 - 4
1989 Sept.- Oct.	97	411	5	19.4	31	1989 Sept.28 - 29
1989 Oct.	110	521	6	18.3	32	1989 Oct. 27 - 28
1989 Nov. - Dec.	91	612	6	15.2	27	1989 Nov. 30 - Dec. 1
1989 Dec.	84	696	2	42.0	70	1989 Dec. 28 - 29
1990 Jan.	55	751	3	18.3	30	1990 Jan. 27 - 28
1990 Feb.	112	863	4	28.0	46	1990 Feb. 26 - 27
1990 Mar.	290	1153	8	36.3	56	1990 Mar. 21 - 22
1990 Apr.	79	1232	4	19.8	36	1990 Apr. 23 - 24
1990 May	66	1298	5	13.2	28	1990 May 24 - 25
1990 June - July	74	1372	5	14.8	34	1990 June 24 - 25
1990 July	110	1482	4	27.5	30	1990 July 19 - 20
1990 Aug.	234	1716	6	39.0	68	1990 Aug. 16 - 17
1990 Sept.	232	1948	5	46.4	70	1990 Sept.18 - 19
1990 Oct.	425	2373	7	60.7	99	1990 Oct. 16 - 17
1990 Nov.	381	2754	7	54.4	83	1990 Nov. 14 - 15
1990 Dec.	411	3165	7	58.7	106	1990 Dec. 13 - 14
1991 Jan.	339	3504	8	42.4	99	1991 Jan. 13 - 14
1991 Feb.	339	3843	7	48.4	83	1991 Feb. 8 - 9
1991 Mar.	433	4276	7	61.9	105	1991 Mar. 16 - 17
1991 Apr.	176	4452	4	44.0	83	1991 Apr. 18 - 19
1991 May	306	4758	6	51.0	72	1991 May 11 - 12
1991 June	177	4935	7	25.3	56	1991 June 13 - 14
1991 July	339	5274	7	48.4	75	1991 July 8 - 9
1991 Aug.	402	5676	5	80.4	111	1991 Aug. 5 - 6
1991 Sept.	432	6108	7	61.7	108	1991 Sept. 8 - 9
1991 Oct.	402	6510	7	57.4	99	1991 Oct. 8 - 9
1991 Nov.	325	6835	7	46.4	111	1991 Nov. 5 - 6
1991 Dec.	99	6934	2	49.5	89	1991 Dec. 4 - 5
1991 Dec. - 1992 Jan.	477	7411	6	79.5	108	1992 Jan. 1 - 2
1992 Feb.	242	7653	4	60.5	91	1992 Feb. 5 - 6
1992 Mar.	157	7810	5	31.4	59	1992 Feb. 29 - Mar. 1
1992 Apr.	65	7875	1	65.0	65	1992 Mar. 31 - Apr. 1

TABLE 1. SUMMARY OF OAK RIDGE OBSERVATIONS (contd.)

1992 Apr. - May	295	8170	6	49.2	79	1992 Apr. 29 - 30
1992 May - June	198	8368	6	33.0	59	1992 June 2 - 3
1992 June - July	215	8583	6	35.8	61	1992 June 28 - 29
1992 July - Aug.	380	8963	7	54.3	71	1992 Aug. 1 - 2
1992 Aug. - Sept.	365	9328	8	45.6	84	1992 Aug. 24 - 25
1992 Sept.- Oct.	369	9697	6	61.5	115	1992 Sept.24 - 25
1992 Oct.	431	10128	7	61.6	141	1992 Oct. 27 - 28
1992 Nov.	238	10366	3	79.3	116	1992 Nov. 28 - 29
1992 Dec.	539	10905	8	67.4	116	1992 Dec. 20 - 21
1993 Jan.	501	11406	7	71.6	112	1993 Jan. 18 - 19
1993 Feb.	394	11800	6	65.7	83	1993 Feb. 20 - 21
1993 Mar.	307	12107	6	51.2	99	1993 Mar. 22 - 23
1993 Apr.	181	12288	6	30.2	63	1993 Apr. 18 - 19
1993 May	110	12398	5	22.0	44	1993 May 23 - 24
1993 June	112	12510	4	28.0	49	1993 June 17 - 18
1993 July	337	12847	8	42.1	71	1993 July 23 - 24
1993 Aug.	245	13092	7	35.0	77	1993 Aug. 21 - 22
1993 Sept.	399	13491	6	66.5	112	1993 Sept.11 - 12
1993 Oct.	354	13845	5	70.8	107	1993 Oct. 18 - 19
1993 Nov.	488	14333	6	81.3	135	1993 Nov. 16 - 17
1993 Dec.	293	14626	4	73.3	106	1993 Dec. 16 - 17
1994 Feb.	113	14739	5	22.6	54	1994 Feb. 6 - 7
1994 Mar.	282	15021	4	70.5	110	1994 Mar. 11 - 12
1994 Apr.	352	15373	6	58.7	101	1994 Apr. 14 - 15
1994 May	387	15760	7	55.3	76	1994 May 14 - 15
1994 June	171	15931	4	42.8	62	1994 June 8 - 9
1994 July	284	16215	5	56.8	87	1994 July 11 - 12
1994 Aug.	283	16498	6	47.2	93	1994 Aug. 8 - 9
1994 Sept.	357	16855	7	51.0	96	1994 Sept. 1 - 2
1994 Oct.	451	17306	9	50.1	117	1994 Oct. 6 - 7
1994 Oct. - Nov.	192	17498	6	32.0	54	1994 Nov. 2 - 3
1995 Jan.	37	17535	4	9.3	21	1995 Jan. 4 - 5
1995 Jan. - Feb.	205	17740	8	25.6	45	1995 Jan. 30 - 31
1995 Feb. - Mar.	471	18211	6	78.5	128	1995 Mar. 4 - 5
1995 Mar. - Apr.	557	18768	7	79.6	110	1995 Mar. 28 - 29
1995 Apr. - May	216	18984	5	43.2	98	1995 May 1 - 2
1995 May - June	177	19161	5	35.4	61	1995 May 30 - 31
1995 June - July	190	19351	5	38.0	72	1995 June 28 - 29
1995 July - Aug.	79	19430	3	26.3	37	1995 July 31 - Aug. 1
1995 Aug.	602	20032	8	75.3	95	1995 Aug. 25 - 26
1995 Sept.	332	20364	5	66.4	146	1995 Sept.27 - 28
1995 Oct.	600	20964	7	85.7	144	1995 Oct. 23 - 24
1995 Nov.	512	21476	5	102.4	158	1995 Nov. 22 - 23
1995 Dec.	290	21766	4	72.5	178	1995 Dec. 22 - 23
1996 Jan.	72	21838	3	24.0	49	1996 Jan. 20 - 21
1996 Feb.	195	22033	4	48.8	93	1996 Feb. 18 - 19
1996 Mar.	563	22596	7	80.4	127	1996 Mar. 16 - 17
1996 Apr.	330	22926	4	82.5	100	1996 Apr. 18 - 19
1996 May	253	23179	7	36.1	70	1996 May 14 - 15
1996 June	80	23259	3	26.7	47	1996 June 14 - 15
1996 July	194	23453	6	32.3	57	1996 July 17 - 18
1996 Aug.	185	23638	6	30.8	71	1996 Aug. 18 - 19
1996 Sept.	87	23725	2	43.5	64	1996 Sept.14 - 15
1996 Oct.	214	23939	6	35.7	75	1996 Oct. 14 - 15
1996 Nov.	301	24240	6	50.2	77	1996 Nov. 11 - 12
1996 Dec.	108	24348	2	54.0	57	1996 Dec. 9 - 10
1997 Jan.	8	24356	1	8.0	8	1997 Jan. 6 - 7
1997 Feb.	5	24361	1	5.0	5	1997 Feb. 9 - 10
1997 Mar.	2	24363	1	2.0	2	1997 Mar. 12 - 13
1997 Apr.	22	24385	2	11.0	12	1997 Apr. 8 - 9
1997 May	6	24391	1	6.0	6	1997 May 7 - 8
1997 June	32	24423	3	10.7	13	1997 June 4 - 5